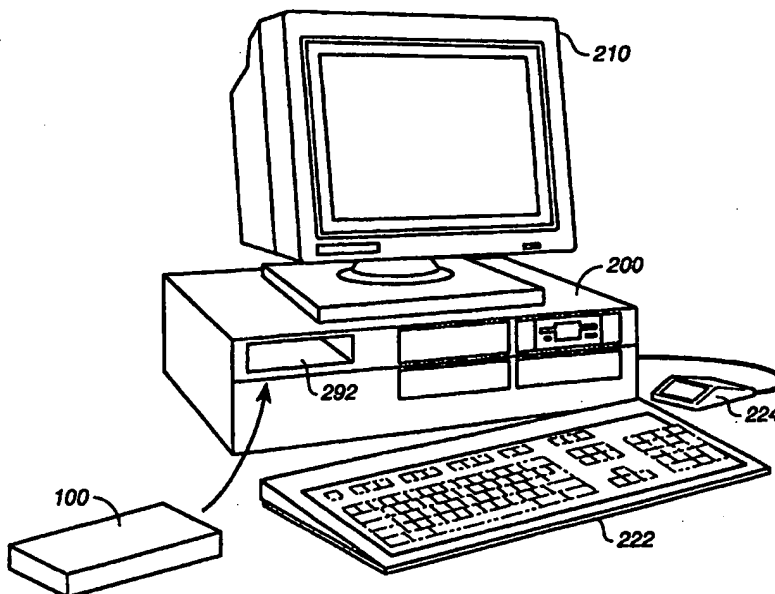


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(54) Title: PERSONAL COMPUTER PERIPHERAL CONSOLE WITH ATTACHED COMPUTER MODULE



## (57) Abstract

An attached computer module (100) (ACM) that mates with a personal computer peripheral console (200) (PCON) to form a fully functional computer is disclosed. The ACM contains high-value components of the computer system in a compact, highly portable form. The PCON provides primary input (222, 224), output (210), and power capability. PCONs may take many forms allowing reuse of the high-value components of the computer system in different use configurations or in geographically disparate locations. The ACM and PCON may be interconnected using a cable-friendly interface with high reliability.

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## PERSONAL COMPUTER PERIPHERAL CONSOLE WITH ATTACHED COMPUTER MODULE

### CROSS-REFERENCE TO RELATED APPLICATIONS

- 5        This application claims any and all benefits as provided by law of U.S. Provisional Application No. 60/083,886 filed May 1, 1998 and of U.S. Provisional Application No. 60/092,706 filed July 14, 1998 and of U.S. Application No. 09/149,548 filed September 8, 1998.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

- 10        The invention relates to the field of personal computers. In particular, the invention relates to a personal computer comprising a computing module that attaches to a mating peripheral console.

#### 2. Description of Related Art

- Most computer systems are designed as standalone, self-contained units. A personal computer (PC) is constructed with a motherboard, enclosed within a case, acting as the central circuit board that connects all devices together including the central processing unit (CPU), system memory, graphics devices, audio devices, communications devices, a power supply, hard disk drive, floppy disk drive, add-on cards, and others. While some components may be exposed to the exterior of the case for easy substitution and replacement, such as removable diskette drives or PCMCIA cards for a notebook computer, the CPU is fixed within the case. A new generation of processor "modules," such as Intel's Mobile CPU module, contain the CPU and certain support circuitry within a pluggable module, but the module is directly attached to the motherboard, enclosed within the computer case, and removed only for servicing. As such, the CPU, which is an expensive component of the computer, cannot be readily utilized apart from the system in which it is installed.
- 15  
20  
25

Improved modular designs for personal computer systems have been suggested in the past. U.S. Patent 5,539,616 (Kikinis) shows a notebook computer comprised almost entirely of pluggable modules. This design wins the advantages most often associated with modularity, i.e., flexibility in configuration and ease of servicing. At this level of modularity, however, no single module is sufficient in itself to preserve the core computing capability and environment of the computer user.

Another approach to personal computer modularity suffers from the same shortcoming. The recently developed Device Bay standard defines a mechanism for easily adding and upgrading PC peripheral devices without opening the computer case. Device Bay supports a wide variety of storage devices. The Device Bay standard supports only peripheral devices, however, and not CPU or memory modules.

Notebook computers with docking stations represent a partitioning of PC components that permits the core computing capability and environment of the user to be isolated to a portable physical package, i.e., the notebook computer. The notebook is self-contained and fully able to operate apart from any docking station, having all core computing capability plus primary input and display devices integrated into a single package. The docking station is an optional accessory that may be used to hold secondary or bulky peripheral devices.

The portability of notebook computers is, however, constrained by several factors. As a fully functional computer system, a notebook computer requires a substantial power supply. Batteries and AC adapters are both heavy limiting the ability to produce a device that is lightweight. A notebook computer also supplies primary input and display devices for the user. Usable keyboards and readable display screens limit the ability to produce a device with small dimensions that can support the software applications most commonly used on personal computers.

The most significant partitioning of a desktop personal computer occurs in the IBM Aptiva S Series. The Aptiva S PC's incorporate a system tower with a physically separate media console connected by a bus cable. The media console contains frequently accessed peripherals, such as CD-ROM and diskette drives, and

has a connection for the keyboard and mouse. This construction removes the bulky tower case from the desktop by locating a small set of low performance peripherals near the monitor, as much as six feet away from the tower. The major components of the system, including the CPU, memory, hard disk drive, add-on cards, power supply, etc., remain together in the tower case.

Consequently, there is a need in the art for a personal computer that allows the user to localize their core computing power and software environment in a small, lightweight, single, portable, physical package.

### SUMMARY OF THE INVENTION

A personal computer system comprising two physically separate units and the interconnection between them is disclosed. The first unit, an attached computing module (ACM), contains the core computing power and environment for a computer user. The second unit, a peripheral console (PCON), contains the power supply and primary input and output devices for the computer system. An ACM and a PCON are coupled with one another to form a fully functional personal computer system.

The ACM is small in size so as to be easily transported between work locations or to a servicing facility. The ACM is of comparable size to that of a videocassette, and similarly has a hard shell to provide mechanical protection for its internal components. The core computing power in the ACM comprises the central processing unit (CPU), system memory, any auxiliary processors, and primary mass storage (e.g., a hard disk drive) which serves as the boot device for the computer system. The user's core environment contained in the ACM comprises the primary operating system software files, frequently used application software files, files containing the user's working data, and stored configuration data that controls various aspects of software operation customized to the user's characteristics or preferences. Notably absent from the ACM are any substantial power supply, and any substantial input/output device such as would normally be used by the computer operator to interact and exploit the range of functionality provided by the operating system and application software.

The PCON provides the remaining components of a personal computer system including substantial power supply and input/output devices. Different PCON designs provide different usage possibilities for the user's core computing power and environment. Example PCON's include desktop computer, notebook  
5 computer, notepad computer, and computer-based entertainment computer designs.

To form a fully operational computer system, an ACM is coupled with a PCON. The plug-in module design of the ACM, and the concentration of high-value components therein (both in terms of high-value hardware and high-value files), makes it easy for a user to transport the high-value core between multiple  
10 PCON's, each of which can enjoy a relatively low cost. The concentration of a user's core computing environment in a small, portable package also makes it possible for large organizations to perform moves, adds, and changes to personal computer systems with greater efficiency.

These and other purposes and advantages of the present invention will  
15 become more apparent to those skilled in the art from the following detailed description in conjunction with the appended drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts an exemplary desktop peripheral console and attached computing module.

20 Figures 2a through 2d depict various peripheral console configurations.

Figure 3 is a block diagram of one embodiment of a computer system employing the present invention.

Figure 4 is a block diagram of an attached computing module (ACM).

Figure 5 illustrates an external view of one embodiment of an ACM.

25 Figure 5b illustrates one possible embodiment of a computer bay.

Figure 6 illustrates the internal component layout for one embodiment of an ACM.

Figure 7 is a block diagram of a peripheral console (PCON).

Figure 8 depicts internal major component placement for one tower desktop  
30 peripheral console (PCON).

Figure 9 depicts internal component placement for one notebook peripheral console (PCON).

In the figures just described, like parts appearing in multiple figures are numbered the same in each figure.

### DETAILED DESCRIPTION

5       **Figure 1** depicts an exemplary desktop peripheral console and attached computing module. The desktop peripheral console (PCON) looks similar to a desktop PC system unit of conventional design. Front covers for device bays and a diskette drive are visible on the front panel of the PCON. The PCON also provides connections for a display monitor, a keyboard, and a mouse.

10       The front panel of the PCON also displays an opening to a computer bay 292. The computer bay acts as the receptacle for the attached computer module (ACM). The ACM houses the core computing power and environment for a particular user and is inserted into the opening of the computer bay to receive power and to interact with the peripheral devices housed in the PCON. The ACM  
15 achieves normal operational capability when mated with a PCON. Because the ACM does not contain a primary power supply or primary input or output devices, it can be small and lightweight. These characteristics make the ACM greatly portable. It can be easily carried in a briefcase with other matter and is thus ideal for transport between home and office, or multiple office locations, each equipped  
20 with a desktop PCON. This represents one advantage of the present invention.

The design of peripheral consoles (PCON's) is in no way limited to the desktop unit as pictured in **Figure 1**. **Figures 2a** through **2d** depict various peripheral console configurations. **Figure 2a** depicts a tower desktop PCON configuration. The opening of the computer bay 292 is visible at the front of the  
25 PCON unit. The PCON provides support for a video monitor as the user's primary display device. The PCON also provides support for a keyboard and a mouse as the user's primary input (text and pointing) devices.

**Figure 2b** depicts a notebook computer PCON configuration. The opening of the computer bay 292 is visible at the side of the PCON unit. The PCON provides an integrated LCD display panel as the user's primary display device. The PCON provides an integrated keyboard as the user's primary input device.

5       **Figure 2c** depicts a notepad computer PCON configuration. The opening of the computer bay 292 is visible along the back side of the PCON unit. The PCON provides an integrated LCD display panel as the user's primary display device. The display panel may be equipped with touch sensitivity to serve as the user's primary input device. The stylus may be used to enter text or graphics, or to select "soft"  
10 buttons, on the touch sensitive screen. Software accessible mechanical switches serve as an alternative primary input mechanism.

**Figure 2d** depicts an entertainment PCON configuration. The opening of the computer bay 292 is visible at the front side of the PCON unit. The PCON provides an integrated television screen as the user's primary display device. A  
15 remote control keypad serves as the user's primary input device.

**Figure 3** is a block diagram of the components in one computer system employing the present invention. The computer system comprises an attached computer module (ACM), a peripheral console (PCON), and the interconnection apparatus between them. The ACM includes the central processing unit (CPU)  
20 110, system memory 120, high performance devices 150, primary mass storage 130, and related interface and support circuitry 140. The PCON includes primary display 210, primary input 220, secondary mass storage 250, other devices 260, expansion slots 270, the primary power supply 230, and related interface and support circuitry 240. The interconnection apparatus 300 includes circuitry to  
25 convey power and operational signals between the ACM and PCON.

Within the ACM 100, the CPU 110 executes instructions and manipulates data stored in the system memory. The CPU 110 and system memory 120 represent the user's core computing power. The core computing power may also include high performance devices 150 such as advanced graphics processor chips  
30 that greatly increase overall system performance and which, because of their speed, need to be located close to the CPU. The primary mass storage 130 contains



persistent copies of the operating system software, application software, configuration data, and user data. The software and data stored in the primary mass storage device represent the user's computing environment. Interface and support circuitry 140 primarily includes interface chips and signal busses that interconnect the CPU, system memory, high performance devices, and primary mass storage. The interface and support circuitry also connects ACM-resident components with the ACM-to-PCON interconnection apparatus as needed.

Within the PCON 200, the primary display component 210 may include an integrated display device or connection circuitry for an external display device.

This primary display device may be, for example, an LCD, plasma, or CRT display screen used to display text and graphics to the user for interaction with the operating system and application software. The primary display component is the primary output of the computer system, i.e., the paramount vehicle by which programs executing on the CPU can communicate toward the user.

The primary input component 220 of the PCON may include an integrated input device or connection circuitry for attachment to an external input device. The primary input may be, for example, a keyboard, touch screen, keypad, mouse, trackball, digitizing pad, or some combination thereof to enable the user to interact with the operating system and application software. The primary input component is the paramount vehicle by which programs executing on the CPU receive signals from the user.

The PCON may contain secondary mass storage 250 to provide additional high capacity storage for data and software. Secondary mass storage may have fixed or removable media and may include, for example, devices such as diskette drives, hard disks, CD-ROM drives, DVD drives, and tape drives.

The PCON may be enhanced with additional capability through the use of integrated "Other Devices" 260 or add-on cards inserted into the PCON's expansion slots 270. Examples of additional capability include sound generators, LAN connections, and modems. Interface and support circuitry 240 primarily includes interface chips, driver chips, and signal busses that interconnect the other components within the PCON. The interface and support circuitry also connects

PCON-resident components with the ACM-to-PCON interconnection apparatus as needed.

Importantly, the PCON houses the primary power supply 230. The primary power supply has sufficient capacity to power both the PCON and the ACM 100 for normal operation. Note that the ACM may include a secondary "power supply" in the form, for example, of a small battery. Such a power supply would be included in the ACM to maintain, for example, a time-of-day clock, configuration settings when the ACM is not attached to a PCON, or machine state when moving an active ACM immediately from one PCON to another. The total energy stored in such a battery would, however, be insufficient to sustain operation of the CPU at its rated speed, along with the memory and primary mass storage, for more than a fraction of an hour, if the battery were able to deliver the required level of electrical current at all.

**Figure 4** is a block diagram of an attached computing module (ACM) 100. The physical ACM package 100 contains the ACM functional components 101 and the ACM side of the ACM-to-PCON Interconnection 300. The ACM 101 comprises a CPU component 110, a system memory component 120, a primary mass storage component 130, a high performance devices components 150, and an interface and support component 140.

The ACM side of the ACM-to-PCON Interconnection 300 comprises a Host Interface Controller (HIC) component 320 and an ACM connector component 330. The HIC 320 and connector 330 components couple the ACM functional components 101 with the signals of an ACM-to-PCON interface bus 310 used to operatively connect an ACM with a PCON. The ACM-to-PCON interface bus 310 comprises conveyance for electrical power 314 and signals for a peripheral bus 312, video 316, video port 317, and console type 318.

The ACM-to-PCON Interconnection 300 conveys certain signals in bit-serial format. The use of bit-serial format reduces the number of physical signal paths required to traverse the interconnection. Additionally, the ACM-to-PCON Interconnection 300 uses differential signaling to convey certain bit-serial data.. Differential signaling, such as low voltage differential signaling (LVDS), can

provide very reliable, high-speed, and low-power transmission across cables -- and cables as a transmission media provide tremendous design flexibility. Accordingly, the use of bit-serial format for computer bus data and the use of differential signaling represent further advantages of the present invention.

5           More specifically, in the presently described embodiment at least the peripheral bus 312 has a plurality of serial bit channels numbering fewer than the number of parallel bus lines in PCI bus 167 and operates at a clock speed higher than the clock speed at which any of the PCI bus lines operates. The peripheral bus 312 includes two sets of unidirectional serial bit channels which transmit data in  
10   opposite directions such that one set of bit channels conveys serial bits from the HIC while the other set conveys serial bits to the HIC. For each cycle of the PCI bus 167 clock, each bit channel of the peripheral bus 312 transmits a packet of multiple serial bits.

HIC 320 includes a number of functional subsections that are not shown  
15   individually in Figure 4. The HIC includes a bus controller to interface with PCI bus 167 and to manage transactions that occur therewith. The HIC also includes a translator coupled to the bus controller to (1) encode control signals from PCI bus 167 into control bits and to decode control bits conveyed by peripheral bus 312 into generated control signals for PCI bus 167, and (2) to manage the movement of data  
20   and address bit information to and from PCI bus 167. Additionally, HIC 320 includes a transmitter and a receiver, each coupled to the translator. The transmitter converts parallel bits representing data, address, and control signals into serial bits and transmits the serial bits to the peripheral bus 312 using differential signaling. The receiver receives serial bits from a differential signal of peripheral bus 312, and  
25   converts the serial bits representing data, address, and control signals into parallel bits.

The CPU component 110 of the ACM functional circuitry 101 of the presently described embodiment comprises a microprocessor 112, which is the chief component of the personal computer system, power supply connection point  
30   113, and cache memory 114 tightly coupled to the microprocessor 112 by the CPU-to-cache bus 174 comprising signal paths for address, data, and control information.

The microprocessor 112 of this embodiment is one of the models from the Pentium II family of processors from Intel Corporation. Microprocessor 112 receives electrical power from power bus 168 via connection point 113. Microprocessor 112 couples to the Host Interface Controller (HIC) 320 via CPU-to-HIC bus 163 comprising signal paths to exchange control information such as an interrupt request. Microprocessor 112 also couples to CPU Bridge 146 via CPU main bus 164 comprising signal paths for address, data, and control information.

The CPU Bridge component 146 of the interface and support circuitry 140 operates to couple the high speed CPU main bus 164 to specialty buses of varying speeds and capability that connect other computer components. The CPU Bridge of the presently described embodiment incorporates memory controller circuitry, advanced graphics processor support circuitry, and a general, industry-standard PCI bus controller in a single package. A CPU Bridge 146 such as the 82443LX PCI/AGP Controller from Intel Corporation may be used.

The system memory component 120 of the ACM functional circuitry 101 in the present embodiment comprises main system memory (RAM) 122, BIOS memory 124, and flash memory 126. The system memory 120 is used to contain data and instructions that are directly addressable by the CPU. The RAM 122 comprises volatile memory devices such as DRAM or SDRAM memory chips that do not retain their stored contents when power is removed. This form of memory represents the largest proportion of total system memory 120 capacity. The BIOS memory 124 comprises non-volatile memory devices such as ROM or EPROM memory chips that retain their stored contents regardless of the application of power and are read-only memory under normal operating conditions. The BIOS memory 124 stores, for example, start-up instructions for the microprocessor 112 and sets of instructions for rudimentary input/output tasks. The flash memory 126 comprises non-volatile memory devices that retain their stored contents regardless of the application of power. Unlike the BIOS non-volatile memory, however, the stored contents of the flash memory 126 are easily changed under normal operating conditions. The flash memory 126 may be used to store status and configuration data, such as security identifiers or ACM specifications like the speed of the

microprocessor 112. Some embodiments may combine the BIOS functions into the flash memory device, thus permitting BIOS contents to be rewritten, improving field upgradability.

The main system memory (RAM) 122 is coupled to memory controller  
5 circuitry resident within the CPU Bridge 146 via direct memory bus 165. The BIOS 124 and flash memory 126 are coupled to HIC 320 via switched memory bus 166. This permits the BIOS 124 and flash 126 memories to be accessed by circuitry in the HIC 320 or other circuitry connected thereto. The direct memory bus 165 and the switch memory bus 166 each comprises conductors to convey  
10 signals for data, address, and control information.

The primary mass storage component 130 of the ACM functional circuitry 101 in the present embodiment comprises a compact hard disk drive with an industry-standard, IDE interface. The hard disk drive (HDD) 132 has a formatted storage capacity sufficient to contain an operating system for the computer,  
15 application software desired by the user, and related user configuration and operating parameter data. The HDD 132 in the present embodiment serves as the "boot" device for the personal computer from which the operating system is loaded into RAM 122 by the start-up program stored in the BIOS 124.

The present HDD 132 has a capacity of approximately 2,000 megabytes to  
20 provide adequate storage for common software configurations and reasonable space for user data. One example of a common software configuration includes the Windows 95 operating system from Microsoft Corporation, a word processing program, a spreadsheet program, a presentation graphics program, a database program, an email program, and a web browser such as Navigator from Netscape  
25 Corporation. The hard disk 132 stores program and data files for each software component, including files distributed by the vendor as well as files created or updated by operation of the software after it is installed. For example, a word processor program may maintain information about a user's identity and latest preferences in an operating system registry file. Or, for example, the web browser  
30 may maintain a file of the user's favorite web sites or most recently viewed web pages. An HDD with 2000 megabyte capacity is readily available in the small size

of hard disk (e.g., 2.5-inch or 3.5-inch) to minimize the space required within the ACM for the primary mass storage device 130.

The HDD 132 is coupled to IDE controller circuitry 148 via IDE bus 172. The IDE controller circuitry 148 is coupled to the CPU Bridge 146 via the Host PCI  
5 bus 167. IDE controllers and busses, and the PCI bus are well known and understood in the industry. The above components operate together to couple the hard disk drive 132 to the microprocessor 112.

The high performance devices component 150 of the ACM functional circuitry 101 in the present embodiment comprises an Advanced Graphics  
10 Processor (AGP) 152. The Model 740 Graphics Device from Intel Corporation may be used in the present embodiment as the AGP.

Increases in computer screen size, graphics resolution, color depth, and visual motion frame rates, used by operating system and application software alike, have increased the computing power required to generate and maintain computer  
15 screen displays. An AGP removes a substantial portion of the graphics computing burden from the CPU to the specialized high-performance processor, but a high level of interaction between the CPU and the specialized processor is nonetheless required. To maximize the effective contribution of having a specialized processor in the presently described embodiment, the AGP 152 is located in the ACM 100,  
20 where it is in close proximity to the microprocessor 112. The AGP 152 is coupled to the microprocessor 112 via the advanced graphics port bus 173 of the CPU Bridge 146. The visual display signal generated by the AGP are conveyed toward actual display devices at the peripheral console (PCON) via video signal bus 170. Video information from a source external to the ACM and appearing as video port  
25 signals 317 may be conveyed to the AGP 152 via video port signal path 171.

Other types of high performance components may be included in different ACM configurations. For example, an interface to an extremely high speed data communication facility may be desirable in some future computer where CPU-to-network interaction is of comparable intensity to today's CPU-to-graphics  
30 interaction. Because such high performance components tend to be high in cost, their inclusion in the ACM is desirable. Inclusion of high cost, high performance

components in the ACM concentrates a user's core computing power and environment in a portable package. This represents a further advantage of the invention.

5       The interface and support component 140 of the ACM functional circuitry 101 in the present embodiment comprises circuitry for power regulation 142, clocking 144, CPU Bridge 146, IDE controller 148, and signal conveyance paths 161-174. The CPU Bridge 146 couples the CPU component 110 of the ACM 100 with the other components of the ACM 120-150 and the CPU-to-PCON Interconnection 300. The CPU Bridge 146 and IDE controller 148 have already  
10       been discussed. Power regulation circuitry 142 receives electrical power via the electrical power conduction path 314 of the CPU-to-PCON Interconnection 300, conditions and distributes it to the other circuitry in the ACM using power distribution bus 168. Such regulation and distribution is well known and understood in the art.

15       Clocking circuitry 144 generates clock signals for distribution to other components within the ACM 100 that require a timing and synchronization clock source. The CPU 110 is one such component. Often, the total power dissipated by a CPU is directly proportional to the frequency of its main clock signal. The presently described embodiment of the ACM 100 includes circuitry that can vary  
20       the frequency of the main CPU clock signal conveyed to the CPU via signal path 162, in response to a signal received from the host interface controller (HIC) 320 via signal path 161. The generation and variable frequency control of clocking signals is well understood in the art. By varying the frequency, the power consumption of the CPU (and thus the entire ACM) can be varied.

25       The variable clock rate generation may be exploited to match the CPU power consumption to the available electrical power. Circuitry in the host interface controller (HIC) 320 of the presently described embodiment adjusts the frequency control signal sent via signal path 161 to the clocking circuitry 144, based on the "console type" information signal 318 conveyed from the peripheral console  
30       (PCON) by the CPU-to-PCON interconnection 300. In this arrangement, the console type signal originating from a desktop PCON, such as depicted in Figure

2a, would result in the generation of a maximum speed CPU clock. The desktop PCON, presumably has unlimited power from an electrical wall outlet and does not need to sacrifice speed for power conservation. The console type signal originating from a notebook PCON, such as depicted in Figure 2b, would, however, result in the generation of a CPU clock speed reduced from the maximum in order to conserve battery power and extend the duration of computer operation obtained from the energy stored in the battery. The console type signal originating from a notepad PCON, such as depicted in Figure 2c, would result in the generation of a CPU clock speed reduced further yet, the notepad PCON presumably having smaller batteries than the notebook PCON. Inclusion of control signals and circuitry to effect a CPU clock signal varying in frequency according to characteristics of the PCON to which the ACM is connected facilitates the movement of the user's core computing power and environment to different work settings, which is a further advantage of the present invention.

Figure 5 illustrates an external view of one embodiment of an ACM. The case 510 of the ACM 100 is generally rectangular in shape, preferably constructed of a strong, lightweight, rigid material that will protect the internal components from mechanical and environmental exposure. Plastics may readily be used to construct the case 510. The case 510 completely surrounds the internal components, being generally an 6-sided box. Figure 5 shows the top 512, right 514, and rear 516 surfaces of the ACM case 510. Rear edges 518 of the case joining the rear surface 516 with its adjoining surfaces may be beveled or rounded to facilitate insertion of the ACM 100 into the computer bay of the PCON. Notches 540 may be formed by projecting small surfaces inward from otherwise generally flat surfaces of the ACM case 510. The notches 540 may be used to engage with mechanical devices mounted in and about a computer bay. Such mechanical devices can be employed to secure the ACM into position within a computer bay for reliability and security. Openings 517 are formed into the rear surface 516 of the ACM case 510 through which to project connectors 330a and 330b. In one embodiment the case 510 is approximately 5.75 inches wide by 6.5 inches deep by 1.6 inches high.



Connectors 330a and 330b are part of the ACM-to-PCON Interconnection as described earlier in reference to **Figures 3 and 4**. When the ACM 100 is inserted into the computer bay of a peripheral console (PCON), connectors 330a and 330b mate with corresponding connectors located at the rear of the computer bay to electrically couple the ACM with the PCON containing the computer bay. The connectors 330a and 330b used in one embodiment are connectors complying with the Device Bay industry standard as documented in "Device Bay Interface Specification," revision 0.85, February 6, 1998. Such connectors have specifically been designed to stand up to the rigors of repeated insertion and withdrawal.

10       Cooling plate 530 forms part of the top surface 512 of ACM 100. The cooling plate 530 may be mounted to, or project through an opening formed in, case 510. Similarly, electromagnetic interference (EMI) / electrostatic discharge (ESD) grounding plate 532 forms part of the right surface 514 of ACM 100. The grounding plate 532 may be mounted to, or project through an opening formed in, 15 case 510. Cooling plate 530 and grounding plate 532 compressively mate with counterparts when the ACM is fully inserted into the computer bay. The counterparts located along the boundaries of the computer bay conduct dangerous heat and electrical charges away from the ACM. Inside the ACM, cooling plate 530 thermally couples to heat-sensitive components such as CPU 110 by methods 20 well known in the art. Similarly, grounding plate 532 electrically couples to EMI/ESD-sensitive components, such as a microprocessor, by methods well known in the art.

LCD display 550 forms part of the right surface 514 of ACM 100. The LCD display may be mounted to, or project through an opening formed in, case 25 510. The LCD display may contain indicators about the status of the ACM. Such indicators may display, for example, the time-of-day from a time-of-day clock contained within the ACM, or the amount of charge remaining in an ACM-resident battery, or certain configuration options recorded in flash memory. The LCD display 550 provides display capability for a limited amount of information, most 30 useful when the ACM is separated from a PCON (and is thus separated from a full-capability, primary display device).

Figure 5b illustrates one possible embodiment of a computer bay. A computer bay 290 acts as a receptacle for lodging an ACM (such as the one shown in Figure 5) within a desktop PCON. The illustrated computer bay 290 provides an ACM with housing and with signal flow, electrical grounding, heat transfer, and mechanical connections. While many physical arrangements between the ACM and PCON are possible, the use of an enclosed computer bay as the one illustrated in Figure 5b offers many advantages. For example, the illustrated computer bay 290 provides physical protection for the ACM. The computer bay may also be easily incorporated into industry standard form factors used in the manufacture of desktop personal computers (e.g., the ACM and associated computer bay could be designed to fit within the volume occupied by a standard-size disk drive).

The computer bay 290 appearing in Figure 5b is shown mounted within the confines of PCON case 202. The computer bay 290 comprises frame 291 and signal flow, grounding, cooling, and locking components as described below. Mounting flanges 298 of frame 291 may be used to attach the computer bay 290 to the PCON structure. The computer bay 290 is prominently defined by frame 291 generally forming a cavity in which to lodge an ACM. As such, the interior cavity formed by frame 291 closely approximates the exterior dimensions of a compatible ACM. The top 293, right 294, and rear 295 sides of the computer bay frame 291 are visible. The computer bay frame 291 also includes substantial bottom and left sides which are not shown. The front side of the frame 291 (not shown) is open to allow the insertion of the ACM. Frame 291 is constructed of metal for strength and to facilitate the conductance of heat and undesired electrical currents away from the ACM.

In the presently described embodiment, the weight of an inserted ACM is largely borne by the bottom side (not shown) of computer bay frame 291. Alternative embodiments are possible where, for example, the weight of the ACM is borne by rails running longitudinally down the right and left sides of the computer bay cavity that engage corresponding grooves running longitudinally down the right and left sides of an ACM.

The computer bay 290 includes a signal conductor component to carry electrical signals between the circuitry in the ACM and the circuitry in the PCON. The signal conductor component comprises connectors 362a and 362b and cables 364. The signal conductor component of the computer bay 290 is logically part of the interconnection apparatus represented in block 300 of **Figure 3**.

The rear sections of connectors 362a and 362b are visible in **Figure 5b**. When an ACM is operatively inserted into the computer bay 290, connectors 362a and 362b mate with corresponding connectors located at the rear of the ACM (e.g., connectors 330a and 330b of **Figure 5**). The signals present on the pins of an inserted ACM's connectors are conducted to the corresponding pins of connectors 362a and 362b, and along corresponding conductors within cables 364, to other circuitry housed within PCON case 201. The connectors 362a and 362b used in one embodiment are connectors complying with the Device Bay industry standard as documented in "Device Bay Interface Specification," revision 0.85, February 6, 1998. Such connectors have specifically been designed to stand up to the rigors of repeated insertion and withdrawal.

The computer bay 290 includes an electrical grounding component comprising spring contact bands 620, opening 622, and a conductive path to a grounding source. The electrical grounding component of the computer bay 290 provides a mating mechanism for the grounding pad 532 (shown in **Figure 5**) on an inserted ACM. As such, the position of opening 622 and spring contact bands 620 corresponds to the position of grounding plate 532 (shown in **Figure 5**) for an ACM fully inserted into the computer bay. The bands 620 attach at their ends to side 294 of the computer bay 290 and are formed to project through opening 622 in the side 294 of the computer bay 290. The bands 620 project far enough through opening 622 so as to extend somewhat into the interior of the cavity into which an ACM is inserted. Spring contact bands 620 are constructed of an elastic, conductive material such as spring steel with a conductive coating. With an ACM inserted into the computer bay 290, elastic forces position contact bands 620 against the grounding plate of an inserted ACM and establish a conductive path to ground potential via the bands' connection to the metallic computer bay case 291 at

ground potential. Alternatively, if the computer bay case 291 is not at ground potential, a dedicated wire (not shown) can be attached from a ground potential source directly to contact bands 620.

Similarly, the computer bay 290 includes a cooling component comprising  
5 heat sink 610, opening 611, mounting pads 612, and springs 614. The cooling component provides a mating mechanism for the cooling pad 530 (shown in **Figure 5**) on an inserted ACM. Heat sink 610 is mounted to project into the interior of the computer bay cavity through opening 611 at the top 293 of computer bay 290. Elastic force from springs 614 positioned against mounting pads 612 hold heat sink  
10 610 in firm physical and thermal contact with the cooling plate 530 (shown in **Figure 5**) of an inserted ACM. Through effective thermal coupling between the ACM's cooling plate and the computer bay's heat sink, heat generated during operation can be conducted away from the ACM, via heat sink 610, to the interior of the PCON where air circulated by a cooling fan can dissipate the heat. Movable  
15 heat sink 610 may also be thermally coupled to computer bay case or frame 291 to provide greater heat-sinking mass and surface area for heat dissipation.

The computer bay 290 includes a locking component comprising latching arm 631, locking tip 631, opening 632, pivots 633 and 634, spring 635, mounting tab 636, release arm 637, and plate 638. The locking component operates to  
20 prevent egress of an inserted ACM from the computer bay 290. Locking tip 631 of the latching arm 630 projects into the computer bay cavity 299 through opening 632 in the side of computer bay 290. The locking tip 631 engages one of the notches 540 (shown in **Figure 5**) formed into the case of an ACM when the ACM is inserted into the computer bay 290. The position of opening 632 and locking tip  
25 631 thus corresponds to the position of a notch 540 (shown in **Figure 5**) in the exterior case 510 of an operatively inserted ACM. The latching arm is pivoted at pin 633 with elastic tension from spring 635 urging locking tip 631 toward the interior of the computer bay cavity 299. The angled, frontward edge of locking tip 631 facilitates displacement of the locking tip toward the exterior of the computer  
30 bay when the solid portion of the ACM case 510 (shown in **Figure 5**) to the rear of

the notch 540 (shown in **Figure 5**) is moving past locking tip 631 as the ACM is inserted into the bay 290.

Release arm 637 is pivotally connected by pin 634 to latching arm 630.

Rearward pressure on release arm 637, such as from a computer operator  
5 depressing a front panel button (not shown) attached to the front surface of plate 638, causes latching arm 630 to pivot about pin 633 in opposition to the force provided by spring 635. Sufficient rearward motion of release arm 637 causes locking tip 631 to disengage adequately from the cavity space 299 to permit removal of the ACM from the computer bay 290.

10 One skilled in the art recognizes that the motion of locking tip 631 could be restricted, controlled, or actuated by a variety mechanical or electrical means. For example, a mechanical lock could be coupled to locking tip 631 to prevent egress of the locking tip from the cavity 299 without a key. Similarly, an electrical actuator such as a solenoid, possibly under software control, could operate to disengage the  
15 locking tip 631 only after entry of a security password by the user. One skilled in the art recognizes that similar alternatives exist regarding many aspects of computer bay construction, and that these alternatives may be employed in varying embodiments without departing from the scope and spirit of the invention.

**Figure 6** illustrates the internal component layout for one embodiment of an  
20 ACM. All components are contained within the confines of the ACM case 510, except for connectors 330a and 330b which extend from the rear of the ACM 100 to engage mating connectors (not shown) that will couple the ACM circuitry with the PCON circuitry. Main circuit board 610 provides electrical connections for circuitry within the ACM and mounting for many of its components 124, 122, 126,  
25 152, 142 148, 320, and 330. The fabrication and use of such circuits boards is well known and understood in the art. Connector 622 is also mounted on main circuit board 610 and mates with mobile processor module 620. Mobile processor module 620 represents a form of packaging for a microprocessor and related components. The illustrated mobile processor module 620 is a self-contained unit that includes a  
30 microprocessor 112, CPU cache 114, and CPU bridge 146 operatively interconnected by the manufacturer. An example of one such module is the

Pentium Processor with MMX Technology Mobile Module from Intel Corporation (order number 24 3515-001, September 1997). One skilled in the art recognizes that discrete microprocessor, cache, and bridge could have been employed and mounted directly to the main circuit board.

5           The mobile processor module 620 blocks the view, from the top, of the system BIOS 124. Similarly, hard disk drive 132 hides RAM memory 122, the high performance graphics processor 152, the host interface controller 320, and flash memory 126. Memory upgrade socket 630 remains exposed to facilitate installation of additional RAM memory 122. Power regulator 142, like the memory  
10 upgrade socket, enjoys a generous amount of overhead clearance to accommodate its vertical size. The area including IDE controller 148 also enjoys overhead clearance to facilitate a cable connection with the hard disk drive 132.

          The functional interconnection and operation of components contained within the ACM and depicted in **Figure 6** has already been described in relation to  
15 **Figure 4** for like numbered items appearing therein.

**Figure 7** is a block diagram of a peripheral console (PCON). A peripheral console couples with an ACM to form an operating personal computer system. The peripheral console (PCON) supplies an ACM with primary input, display, and power supply; the ACM supplies the core computing power and environment of the  
20 user. In the presently described embodiment the physical PCON package 200 contains the PCON functional components 201 and the PCON side of the ACM-to-PCON Interconnection 300. The PCON functional components 201 comprise primary display 210, a primary input 220, a primary power supply 230, interface and support 240, secondary mass storage 250, other devices 260, and expansion  
25 slots 270.

          The PCON side of the ACM-to-PCON Interconnection 300 comprises a Peripheral Interface Controller (PIC) component 340, a PCON connector component 350, console-type component 342, and flash memory device 348. The PIC 340 and connector 350 components couple the PCON functional components  
30 201 with the signals of an ACM-to-PCON interface bus 310 used to operatively connect an ACM with a PCON. The ACM-to-PCON interface bus 310 comprises

conveyance for electrical power 314 and signals for a peripheral bus 312, video 316, video port 317, and console-type 318.

The PCON side of the ACM-to-PCON Interconnection 300 operates as a counterpart to the ACM side described earlier in reference to **Figure 4**.

- 5 Accordingly, the ACM-to-PCON interconnection 300 shown in **Figure 7** conveys certain signals in bit-serial format. The ACM-to-PCON Interconnection 300 also uses differential signaling to convey certain bit-serial data.

- More specifically, in the presently described embodiment at least the peripheral bus 312 has a plurality of serial bit channels numbering fewer than the  
10 number of parallel bus lines in PCI bus 241 and operates at a clock speed higher than the clock speed at which any of the PCI bus lines operates. The peripheral bus 312 includes two sets of unidirectional serial bit channels which transmit data in opposite directions such that one set of bit channels conveys serial bits from the PIC while the other set conveys serial bits to the PIC. For each cycle of the PCI  
15 bus 241 clock, each bit channel of the peripheral bus 312 transmits a packet of multiple serial bits.

- PIC 340 includes a number of functional subsections that are not shown individually in **Figure 4**. The PIC includes a bus controller to interface with PCI bus 241 and to manage transactions that occur therewith. The PIC also  
20 includes a translator coupled to the bus controller to (1) encode control signals from PCI bus 241 into control bits and to decode control bits conveyed by peripheral bus 312 into generated control signals for PCI bus 241, and (2) to manage the movement of data and address bit information to and from PCI bus 241. Additionally, PIC 340 includes a transmitter and a receiver, each coupled to the  
25 translator. The transmitter converts parallel bits representing data, address, and control signals into serial bits and transmits the serial bits to the peripheral bus 312 using differential signaling. The receiver receives serial bits from a differential signal of peripheral bus 312, and converts the serial bits representing data, address, and control signals into parallel bits.

- 30 Connector component 350 may be selected to mate directly with the connector component 330 of an ACM (shown in **Figure 4**). Alternatively,

connector component 350 may be selected to mate with, for example, the connector on one end of a cable intervening between the PCON and an ACM in a particular embodiment, such as cable 364 shown in **Figure 5B**. The ACM-to-PCON interconnection herein described has the advantage of providing reliable signal conveyance across low cost cables.

Flash memory device 348 provides non-volatile storage. This storage may be accessible to devices in both the ACM and the PCON, including the host interface controller and the peripheral interface controller to which it is connected. As such, flash memory 348 may be used to store configuration and security data to facilitate an intelligent mating between an ACM and a PCON that needs no participation of the CPU.

The primary display component 210 of the PCON functional circuitry 201 of the presently described embodiment comprises integrated display panel 212 and video connector 213. Integrated display panel 212 is a color LCD display panel having a resolution of 640 horizontal by 480 vertical pixels. 640-by-480 resolution is popularly considered to be the minimum screen size to make practical use of the application software in widespread use today. One skilled in the art recognizes that the type and resolution of the display can vary greatly from embodiment to embodiment, depending on factors such as cost and intended application. Any display device may be used, without departing from the scope and spirit of the invention, that provides principal visual output to the computer user for operating system and application software executing in its customary and intended fashion using the CPU component (110 of **Figure 3**) of an ACM presently coupled to PCON 200.

Integrated display panel 212 is coupled to video signal bus 249 and displays a screen image in response to video signals presented on bus 249. Certain pins of connector 350 receive video output signals 316 of the ACM-to-PCON interface bus 310 from a mated connector that is coupled to an ACM. These certain pins of connector 350 couple to video signal bus 249 which conveys the video output signals 316 throughout the PCON 200 as needed. Video connector 213 is exposed at the exterior of PCON 200 and couples to video signal bus 249. Connector 213



permits easy attachment of an external display device that is compatible with the signals carried by bus 249, such as a CRT monitor (not shown). The external display device may be used in addition, or as an alternative, to integrated display panel 212.

5           The isolation of the relatively heavy and sizable primary display 210 from the core computing power and user environment contained within an ACM represents a further advantage of the present invention.

          The primary input component 220 of the PCON functional circuitry 201 of the presently described embodiment comprises keyboard interface circuitry 222,  
10   keyboard connector 223, pointer interface circuitry 224, and pointer connector 225. Keyboard interface circuitry 222 and pointer interface circuitry 224 connect to ISA bus 245 and are thereby coupled to the CPU component (110 of Figure 3) of any ACM attached to PCON 200. Keyboard interface circuitry 222 interfaces a  
15   standard computer keyboard (not shown), attached at connector 223, to ISA bus 245. Pointer interface circuitry 222 interfaces a standard computer pointing device (not shown), such as a computer mouse attached at connector 225, to ISA bus 245. Computer keyboards, pointing devices, connectors 223, 225, keyboard interface circuitry 222, and pointer interface circuitry 224 are well known in the art. The  
20   isolation of the relatively heavy and sizable primary input devices 220 from the core computing power and user environment contained within an ACM represents a further advantage of the present invention.

          The primary power supply component 230 of the PCON functional circuitry 201 of the presently described embodiment provides electrical energy for the sustained, normal operation of the PCON 200 and any ACM coupled to connector  
25   350. The power supply may be of the switching variety well known in the art that receives electrical energy from an AC source 289, such as a wall outlet. Power supply 230 reduces the alternating current input voltage, to a number of distinct outputs of differing voltages and current capacities. The outputs of power supply 230 are applied to power bus 231. Power bus 231 distributes the power supply  
30   outputs to the other circuitry within the PCON 200. Bus 231 also connects to certain pins of connector 350 to provide the electrical power 314 for an ACM

conveyed by ACM-to-PCON interconnection 300. The isolation of the usually heavy power supply 230 from the core computing power and user environment contained within the ACM represents a further advantage of the present invention.

The interface and support component 240 of the PCON functional circuitry 201 of the presently described embodiment comprises peripheral bridge 246, diskette controller 242, IDE controller 248, and signal conveyance paths 241, 243, 244, 245, 247 and 249. Peripheral bridge 246 couples PCI peripheral bus 241 with peripheral busses of other formats such as ISA peripheral bus 245 and others 247. PCI and ISA peripheral busses are industry standards, well known and understood in the art. Other peripheral busses 247 may include, for example, a bus compliant with the universal serial bus (USB) industry standard. While other embodiments of a peripheral console 200 may include a single peripheral bus that is coupled to an attached ACM via ACM-to-PCON interconnection 300, such as PCI bus 241, this embodiment includes peripheral bridge 246 to establish additional busses 245, 247. The additional busses 245, 247 permit the use of the many low-cost and readily available components compatible with these bus specifications.

Diskette controller 242 interfaces a floppy disk drive 254 with the CPU component 110 of an attached ACM (shown in Figure 4) so that the CPU may control and use the diskette drive 254 hardware to store and retrieve data. Diskette controller 242 couples to the CPU via a connection to ISA bus 245. Diskette controller 242 connects to the diskette drive 254 via one of device cables 243.

Similarly, IDE controller 248 interfaces a hard disk drive 252 and a CD-ROM drive 256 with the CPU component 110 of an attached ACM (shown in Figure 4) so that the CPU may control and use the hard disk drive 252 and CD-ROM 256 hardware to store and retrieve data. IDE controller 248 couples to the CPU via connection to PCI peripheral bus 241. IDE controller 248 connects to each of hard disk drive 252 and CD-ROM drive 256 via one of device cables 243. Some embodiments of PCON 200 may take advantage of VLSI integrated circuits such as an 82371SB (PIIX4) integrated circuit from Intel Corporation. An 82371SB integrated circuit includes circuitry for both the peripheral bridge 246 and the IDE controller 248 in a single package.

The secondary mass storage component 250 of the PCON functional circuitry 201 of the presently described embodiment comprises diskette drive 254, hard disk drive 252, and CD-ROM drive 256. Secondary mass storage 250 generally provides low-cost, non-volatile storage for data files which may include software program files. Data files stored on secondary mass storage 250 are not part of a computer user's core computing power and environment. Secondary mass storage 250 may be used to store, for example, seldom used software programs, software programs that are used only with companion hardware devices installed in the same peripheral console 200, or archival copies of data files that are maintained in primary mass storage 150 of an ACM (shown in **Figure 4**). Storage capacities for secondary mass storage 250 devices may vary from the 1.44 megabytes of the 3.5-inch high density diskette drive 254, to more than 10 gigabytes for a large format (5-inch) hard disk drive 252. Hard disk drive 252 employs fixed recording media, while diskette drive 254 and CD-ROM drive 256 employ removable media. Diskette drive 254 and hard disk drive 252 support both read and write operations (i.e., data stored on their recording media may be both recalled and modified) while CD-ROM drive 256 supports only read operations.

The other devices component 260 of the PCON functional circuitry 201 of the presently described embodiment comprises a video capture card. A video capture card accepts analog television signals, such as those complying with the NTSC standard used for television broadcast in the United States, and digitizes picture frames represented by the analog signal for processing by the computer. Video capture cards at present are considered a specialty, i.e., not ubiquitous, component of personal computer systems. Digitized picture information from video capture card 260 is carried via signal conveyance path 244 to the peripheral interface controller 340 which transforms it to the video port signals 317 of the ACM-to-PCON interconnection 300 for coupling to the advanced graphics processor 152 in an attached ACM (shown in **Figure 4**).

Video capture card 260 is merely representative of the many types of "other" devices that may be installed in a PCON to expand the capabilities of the personal computer. Sound cards and laboratory data acquisition cards are other

examples. Video capture card 260 is shown installed in one of expansion slots 270 for coupling to the interface and control circuitry 240 of the PCON. Any of other devices 260 could be coupled to the interface and control circuitry 240 of the PCON by different means, such as direct installation on the circuit board that includes the interface and control circuitry 240; e.g., a motherboard.

The expansion slots component 270 of the PCON functional circuitry 201 of the presently described embodiment comprises PCI connectors 271 and ISA connectors 272. A circuit card may be inserted into one of the connectors 271, 272 in order to be operatively coupled with the CPU 110 of an attached ACM (shown in **Figure 4**). Each of connectors 271 electrically connects to PCI bus 241, and may receive and hold a printed circuit card which it electrically couples to PCI bus 241. Each of connectors 272 electrically connects to ISA bus 245, and may receive and hold a printed circuit card which it electrically couples to ISA bus 245. The PCI 241 and ISA 245 busses couple to the CPU 110 of an attached ACM (shown in **Figure 4**) by circuitry already described.

**Figure 8** depicts internal major component placement for one tower desktop peripheral console (PCON). The components shown belong to desktop tower PCON 200 and are housed in PCON case 202, except for ACM 100. Motherboard 810 is mounted parallel to the right side of PCON case 202. This orientation is employed to comport with industry standard form factors for motherboards and desktop computer cases. Motherboard 810 provides mounting and interconnection for much of the circuitry of the PCON. For example, for the PCON embodiment illustrated in **Figure 7**, PCON-side interconnection circuitry 300, interface and control circuitry 240, keyboard 222 and pointer 224 interface circuitry, and expansion slot 270 components, could all be installed on motherboard 810.

Computer bay 290 is mounted with its front opening exposed at the front face of PCON case 202 allowing easy insertion of ACM 100. The long edge of the front opening of computer bay 292 runs perpendicular to the plane of motherboard 810. This orientation is employed to comport with industry standard form factors for desktop computer cases. Cable 364 carries signals between the ACM 100 and motherboard 810 containing PCON-side interconnection circuitry (not specifically

shown). Signals flow between cable 364 and ACM 100 over connectors 330, 362 mated when the ACM is inserted into the computer bay.

Because the rear face of computer bay 290 which holds connectors 362 runs perpendicular to the plane of motherboard 810, the use of a flexible cable simplifies the interconnection between them. Use of the ACM-to-PCON Interface already described facilitates the use of flexible cable.

Figure 8 also depicts CD-ROM 256, power supply 230, PCI expansion slot 271, and an "other device" 260, occupying positions that generally comport with form factors norms at use in the personal computer industry. Other Device 260 comprises a PCI expansion card plugged into PCI expansion slot 271.

Figure 9 depicts internal component placement for one notebook peripheral console (PCON) such as the one illustrated in Figure 2b. Figure 9 shows a view from the top, with the hinged panel containing a display 212 opened as shown in Figure 2b, and with the keyboard and other top surfaces of the base portion 902 removed to allow a view of the interior. Motherboard 910 sits low within the base portion 902 of the notebook PCON 200. The motherboard lies in a plane parallel to the bottom surface of the base portion 902. Motherboard 910 provides mounting and interconnection for circuitry elements such as Peripheral Interface Controller 340, keyboard connector 223, pointer connector 225, and LCD display panel connector 920, and many others that are not shown.

Computer bay 290, battery 230, CD-ROM 256, and PCMCIA slots 930 are placed above motherboard 910. Computer bay 290 has its "front" opening 292 exposed at the right side of the notebook PCON case 202 to permit side insertion of an ACM into the computer bay 292. CD-ROM drive 256 has its front face exposed at the front face of notebook PCON case 202 to permit easy insertion and removal of CD media. Battery 230 which serves as the primary power supply for the notebook PCON has one face exposed at the left side of notebook PCON case 202 to facilitate insertion and removal of the battery 230. PCMCIA slots 930 are exposed at the right side of PCON case 202 to facilitate insertion and removal of PCMCIA cards into and from the slots 930.

PCMCIA cards are credit-card sized electronics modules that extend the functionality of a personal computer system. PCMCIA cards and slots are well known and understood in the art. A PCMCIA card may, for example, contain a modem or network interface electronics.

- 5           The keyboard (not shown) of notebook PCON 200 is placed in a plane generally parallel to Motherboard 910, toward the front edge of notebook PCON 200, and above CD-ROM 256 and computer bay 290.

- 10           Various modifications to the preferred embodiment can be made without departing from the spirit and scope of the invention. (A limited number of modifications have already been described in the preceding discussion.) For example, a particular embodiment may insert another layer of bus bridging between the CPU bridge and the Peripheral bridge. This may be desirable if, for example, a vendor wants to implement a proprietary, general-purpose bus having intermediate
- 15           performance characteristics that fall between those of the high-performance general purpose bus originating at the CPU, and the slower general purpose PCI bus. Thus, the foregoing description is not intended to limit the invention as set forth.

## CLAIMS

What is claimed:

1. A detachable computing module for attachment to a peripheral console  
5 for forming a fully operational personal computer system comprising:
  - an enclosure;
  - a CPU;
  - memory coupled to said CPU;
  - mass storage coupled to said CPU;
  - 10 interconnection circuitry coupled to said CPU, said interconnection circuitry connectable to a peripheral console;
  - wherein said CPU is uncoupled from any primary input circuitry when said interconnection circuitry is disconnected from a peripheral console.
2. The apparatus of Claim 1 further comprising clock circuitry having a  
15 variable frequency output signal coupled to said CPU.
3. The apparatus of Claim 2 wherein said clock circuitry varies the frequency of said output signal in response to a signal presented at an input coupled to said interconnection circuitry.
4. The apparatus of Claim 3 wherein said signal presented at an input  
20 coupled to said interconnection circuitry conveys at least one functional characteristic of a peripheral console.
5. The apparatus of Claim 1 further comprising a cooling plate exposed to the exterior of said computing module and thermally coupled to said CPU.
6. The apparatus of Claim 1 further comprising a grounding plate exposed  
25 to the exterior of said computing module and electrically coupled to an electrical ground connection of the CPU.
7. The apparatus of Claim 1 wherein said enclosure further comprises projections forming a notch for engaging a latching mechanism.
- 30 8. A detachable computing module for attachment to a peripheral console for forming a fully operational personal computer system comprising:

an enclosure;  
a CPU;  
memory coupled to said CPU;  
mass storage coupled to said CPU;  
5 interconnection circuitry coupled to said CPU, said interconnection  
circuitry connectable to a peripheral console;

wherein said CPU is uncoupled from any primary output circuitry  
when said interconnection circuitry is disconnected from a peripheral console.

9. The apparatus of Claim 8 further comprising clock circuitry having a  
10 variable frequency output signal coupled to said CPU.

10. The apparatus of Claim 9 wherein said clock circuitry varies the  
frequency of said output signal in response to a signal presented at an input coupled  
to said interconnection circuitry.

11. The apparatus of Claim 10 wherein said signal presented at an input  
15 coupled to said interconnection circuitry conveys at least one functional  
characteristic of a peripheral console.

12. The apparatus of Claim 8 further comprising a cooling plate exposed to  
the exterior of said computing module and thermally coupled to said CPU.

13. The apparatus of Claim 8 further comprising a grounding plate exposed  
20 to the exterior of said computing module and electrically coupled to an electrical  
ground connection of the CPU.

14. The apparatus of Claim 8 wherein said enclosure further comprises  
projections forming a notch for engaging a latching mechanism.

25 15. A detachable computing module for attachment to a peripheral console  
for forming a fully operational personal computer system comprising:

an enclosure;  
a CPU having a power supply connection point;  
memory coupled to said CPU;  
30 mass storage coupled to said CPU;



interconnection circuitry coupled to said CPU, said interconnection circuitry connectable to a peripheral console;

wherein said power supply connection point of said CPU is uncoupled from any electrical power source having sufficient energy to sustain execution of instructions by said CPU whenever said interconnection circuitry is disconnected from a peripheral console.

16. The apparatus of Claim 15 further comprising clock circuitry having a variable frequency output signal coupled to said CPU.

17. The apparatus of Claim 16 wherein said clock circuitry varies the frequency of said output signal in response to a signal presented at an input coupled to said interconnection circuitry.

18. The apparatus of Claim 17 wherein said signal presented at an input coupled to said interconnection circuitry conveys at least one functional characteristic of a peripheral console.

19. The apparatus of Claim 15 further comprising a cooling plate exposed to the exterior of said computing module and thermally coupled to said CPU.

20. The apparatus of Claim 15 further comprising a grounding plate exposed to the exterior of said computing module and electrically coupled to an electrical ground connection of the CPU.

21. The apparatus of Claim 15 wherein said enclosure further comprises projections forming a notch for engaging a latching mechanism.

22. A detachable computing module for attachment to a peripheral console for forming a fully operational personal computer system comprising:

an enclosure;  
a CPU;  
memory coupled to said CPU;  
mass storage coupled to said CPU;  
interconnection circuitry coupled to said CPU, said interconnection circuitry connectable to a peripheral console; and

power supply circuitry having a stored energy capacity no greater than the energy required to power said CPU, memory, and mass storage for 30 minutes of operation at the maximum rated speed of the CPU.

23. The apparatus of Claim 22 further comprising clock circuitry having a  
5 variable frequency output signal coupled to said CPU.

24. The apparatus of Claim 23 wherein said clock circuitry varies the frequency of said output signal in response to a signal presented at an input coupled to said interconnection circuitry.

25. The apparatus of Claim 24 wherein said signal presented at an input  
10 coupled to said interconnection circuitry conveys at least one functional characteristic of a peripheral console.

26. The apparatus of Claim 22 further comprising a cooling plate exposed to the exterior of said computing module and thermally coupled to said CPU.

27. The apparatus of Claim 22 further comprising a grounding plate  
15 exposed to the exterior of said computing module and electrically coupled to an electrical ground connection of the CPU.

28. The apparatus of Claim 22 wherein said enclosure further comprises projections forming a notch for engaging a latching mechanism.

20 29. A detachable computing module for attachment to a peripheral console for forming a fully operational personal computer system comprising:

an enclosure;

a CPU having a power supply connection point;

memory coupled to said CPU;

25 mass storage coupled to said CPU;

interconnection circuitry coupled to said CPU, said interconnection circuitry connectable to a peripheral console; and

wherein said power supply connection point of said CPU conducts more than 20 percent of the power required for operation of the CPU at its  
30 maximum rated clock speed for no more than 30 minutes for any duration wherein

said interconnection circuitry is continuously disconnected from a peripheral console.

30. The apparatus of Claim 29 further comprising clock circuitry having a variable frequency output signal coupled to said CPU.

5        31. The apparatus of Claim 30 wherein said clock circuitry varies the frequency of said output signal in response to a signal presented at an input coupled to said interconnection circuitry.

32. The apparatus of Claim 31 wherein said signal presented at an input coupled to said interconnection circuitry conveys at least one functional  
10        characteristic of a peripheral console.

33. The apparatus of Claim 29 further comprising a cooling plate exposed to the exterior of said computing module and thermally coupled to said CPU.

34. The apparatus of Claim 29 further comprising a grounding plate exposed to the exterior of said computing module and electrically coupled to an  
15        electrical ground connection of the CPU.

35. The apparatus of Claim 29 wherein said enclosure further comprises projections forming a notch for engaging a latching mechanism.

36. An apparatus as in one of Claims 1-35 wherein said interconnection circuitry conveys peripheral bus signals from multiple parallel paths as sequential  
20        data bits on a single signal path.

37. An apparatus as in one of Claims 1-35 wherein said interconnection circuitry conveys electrical power, and signals comprising video output and peripheral bus information.

38. An apparatus as in one of Claims 1-35 wherein said interconnection  
25        circuitry conveys electrical power, and signals comprising video output, video port, and peripheral bus information.

39. A peripheral console for attachment to a detachable computing module for forming a fully operational personal computer system comprising:  
30        a power supply;

interconnection circuitry coupled to said power supply, said interconnection circuitry connectable to a computing module and for transmitting and receiving parallel computer bus signals as serial bit data streams;

40. The apparatus of Claim 39 further comprising a computer bay for  
5 holding an attached computing module.

41. The apparatus of Claim 40 wherein said computer bay further comprises a latching arm for mechanically engaging an attached computing module occupying said computer bay.

42. The apparatus of Claim 40 wherein said computer bay further  
10 comprises a heat sink.

43. The apparatus of Claim 42 wherein said heat sink comprises a dislocatable surface for applying pressure against an attached computing module occupying said computer bay.

44. The apparatus of Claim 40 wherein said computer bay further  
15 comprises a grounding contact.

45. The apparatus of Claim 44 wherein said grounding contact comprises a dislocatable surface for apply pressure against an attached computing module occupying said computer bay.

46. A personal computer system wherein the core computing power and  
20 environment for a computer user can be readily separated and transported from the remaining computer system components comprising:

(a) a detachable computing module including

an enclosure,

a CPU,

25 memory coupled to said CPU,

mass storage coupled to said CPU, and

(b) a peripheral console comprising a power supply;

(c) interconnection circuitry coupled to said computing module and  
to said peripheral console for conveying electrical power and signals between said  
30 computing module and said peripheral console;

wherein said CPU is uncoupled from any primary input circuitry when said computing module is disconnected from said peripheral console.

47. The apparatus of Claim 46 wherein said interconnection circuitry conveys computer bus signals from multiple parallel signal paths as sequential data  
5 bits on a single signal path.

48. A personal computer system wherein the core computing power and environment for a computer user can be readily separated and transported from the remaining computer system components comprising:

10 (a) a detachable computing module including  
an enclosure,  
a CPU,  
memory coupled to said CPU,  
mass storage coupled to said CPU, and

15 (b) a peripheral console comprising a power supply;

(c) interconnection circuitry coupled to said computing module and to said peripheral console for conveying electrical power and signals between said computing module and said peripheral console;

wherein said CPU is uncoupled from any primary output circuitry  
20 when said computing module is disconnected from said peripheral console.

49. The apparatus of Claim 48 wherein said interconnection circuitry conveys computer bus signals from multiple parallel signal paths as sequential data bits on a single signal path.

25 50. A personal computer system wherein the core computing power and environment for a computer user can be readily separated and transported from the remaining computer system components comprising:

(a) a detachable computing module including  
an enclosure,  
30 a CPU having a power supply connection point,  
memory coupled to said CPU,

mass storage coupled to said CPU, and  
(b) a peripheral console comprising a power supply;  
(c) interconnection circuitry coupled to said computing module and  
to said peripheral console for conveying electrical power and signals between said  
5 computing module and said peripheral console;

wherein said power supply connection point of said CPU is  
uncoupled from any electrical power source having sufficient energy to sustain  
execution of instructions by said CPU whenever said computing module is  
disconnected from said peripheral console.

10 51. The apparatus of Claim 50 wherein said interconnection circuitry  
conveys computer bus signals from multiple parallel signal paths as sequential data  
bits on a single signal path.

52. A personal computer system wherein the core computing power and  
15 environment for a computer user can be readily separated and transported from the  
remaining computer system components comprising:

(a) a detachable computing module including  
an enclosure,  
a CPU,  
20 memory coupled to said CPU,  
mass storage coupled to said CPU, and  
power supply circuitry having a stored energy capacity no  
greater than the energy required to power said CPU, memory, and mass storage for  
30 minutes of operation at the maximum rated speed of the CPU;  
25 (b) a peripheral console comprising a power supply; and  
(c) interconnection circuitry coupled to said computing module and  
to said peripheral console for conveying electrical power and signals between said  
computing module and said peripheral console.

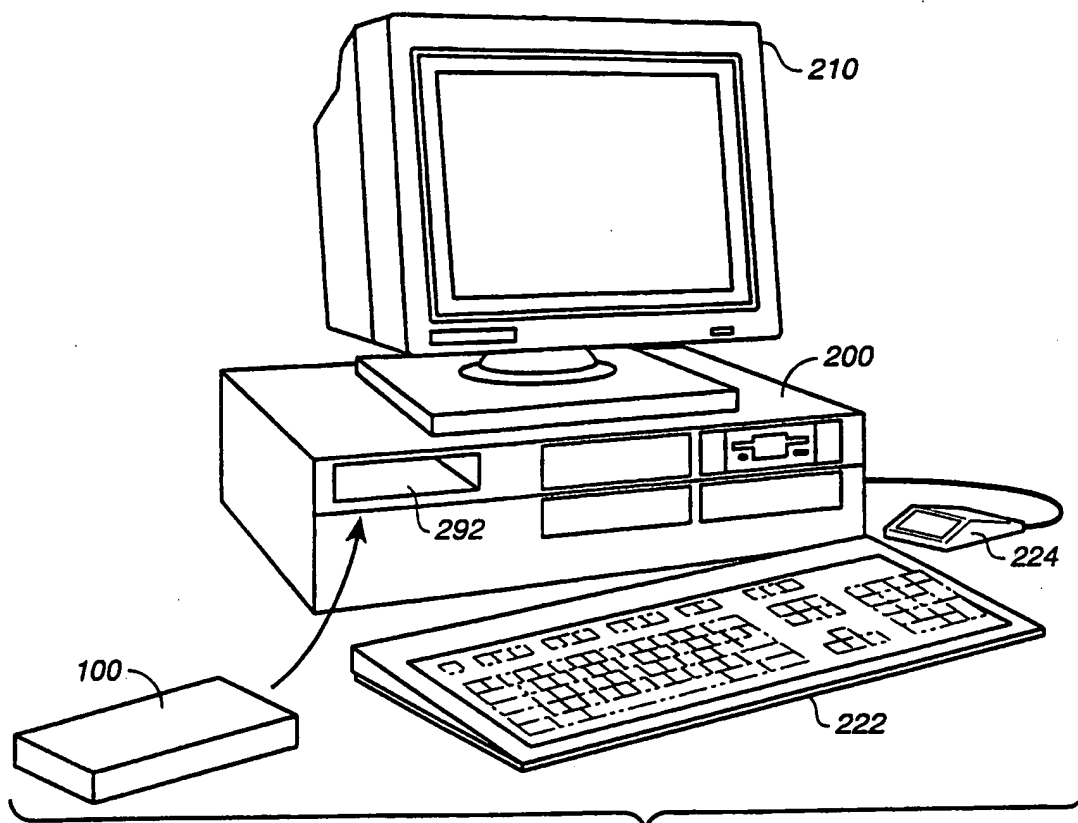
53. The apparatus of Claim 52 wherein said interconnection circuitry conveys computer bus signals from multiple parallel signal paths as sequential data bits on a single signal path.

5           54. A personal computer system wherein the core computing power and environment for a computer user can be readily separated and transported from the remaining computer system components comprising:

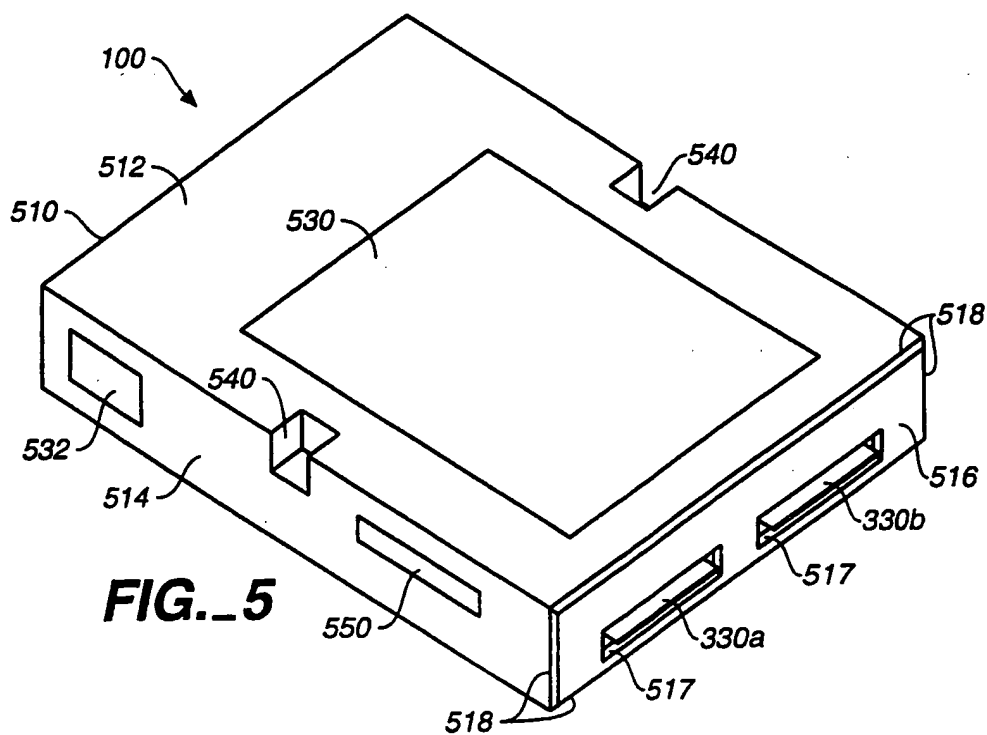
- (a) a detachable computing module including
  - an enclosure,
  - 10           a CPU having a power supply connection point,
  - memory coupled to said CPU, and
  - mass storage coupled to said CPU;
- (b) a peripheral console comprising a power supply;
- (c) interconnection circuitry coupled to said computing module and
- 15   to said peripheral console for conveying electrical power and signals between said computing module and said peripheral console;
- wherein said power supply connection point of said CPU conducts more than 20 percent of the power required for operation of the CPU at its maximum rated clock speed for no more than 30 minutes for any duration wherein
- 20   said interconnection circuitry is continuously disconnected from a peripheral console.

55. The apparatus of Claim 54 wherein said interconnection circuitry conveys computer bus signals from multiple parallel signal paths as sequential data bits on a single signal path.

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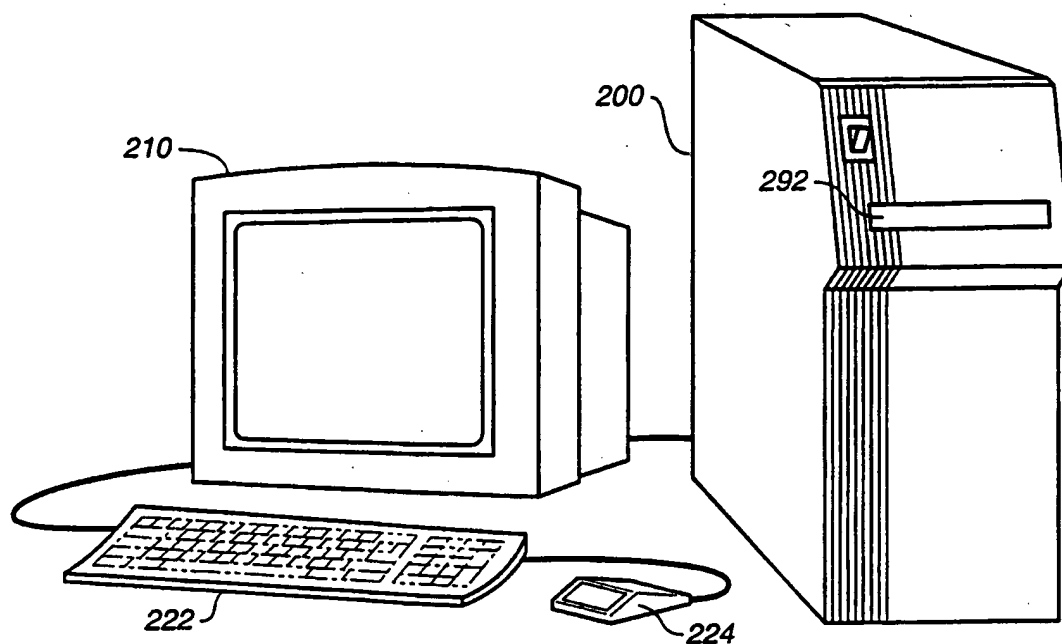
**FIG. 1**



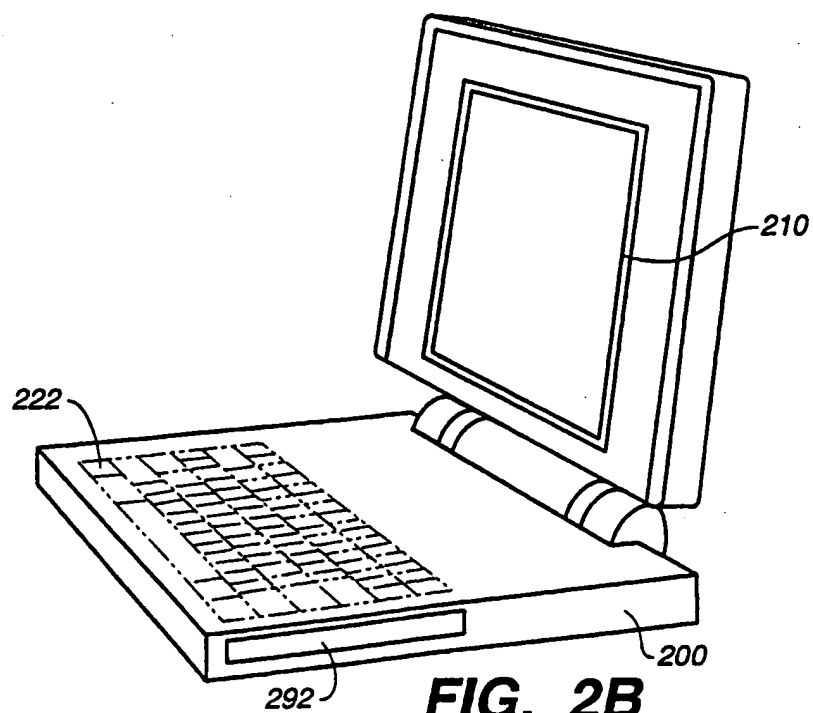
**FIG. 5**



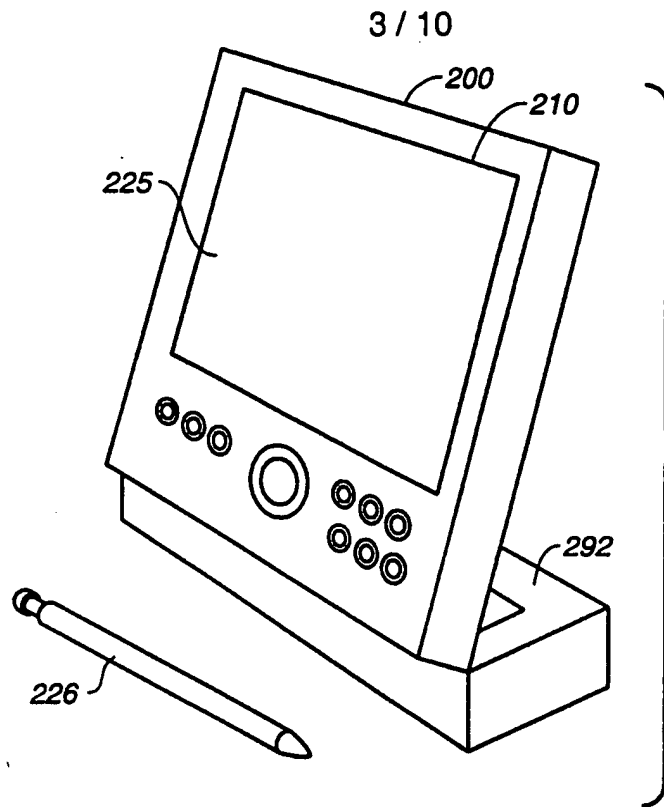
2 / 10



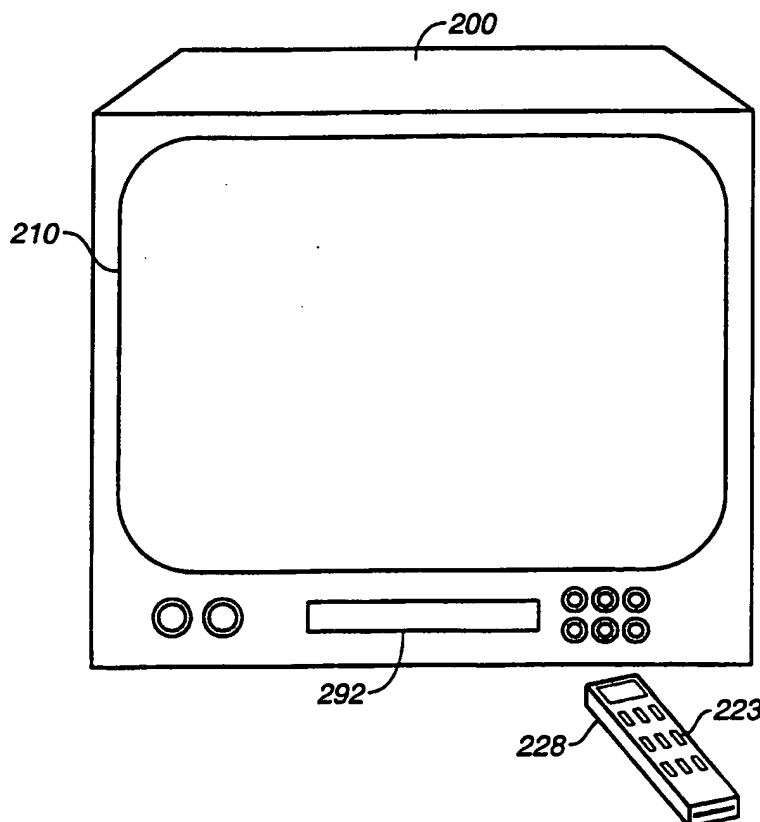
**FIG. 2A**



**FIG. 2B**

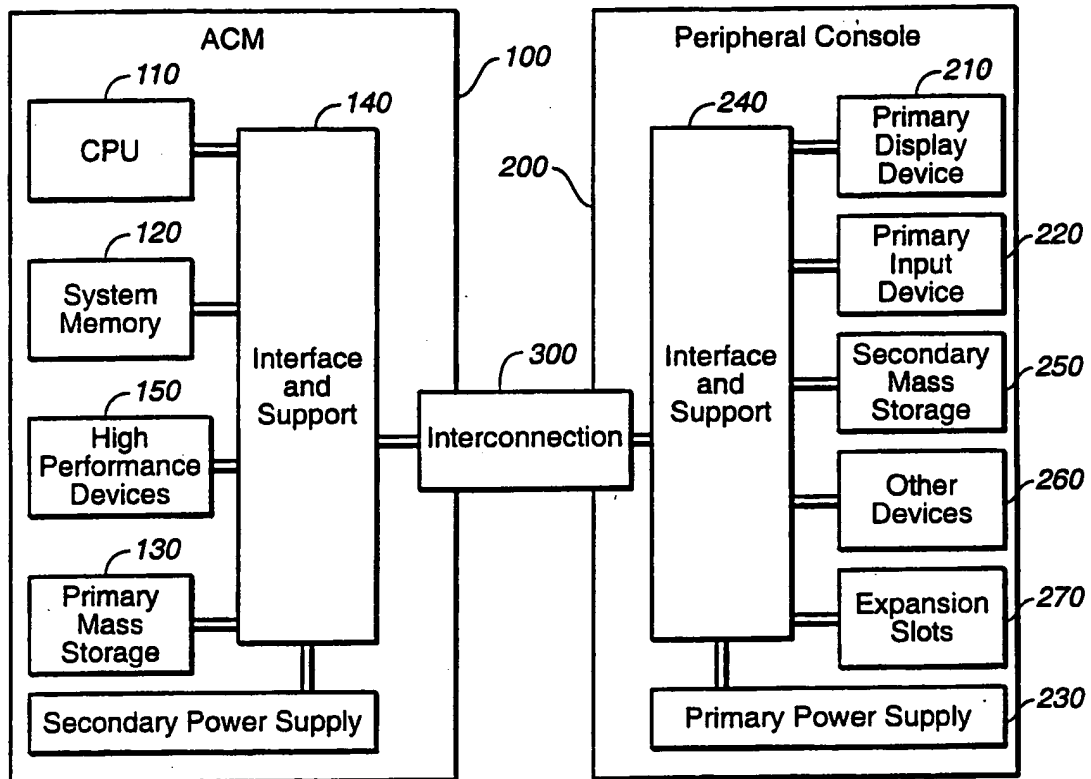


**FIG. 2C**



**FIG. 2D**

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**FIG.\_3**

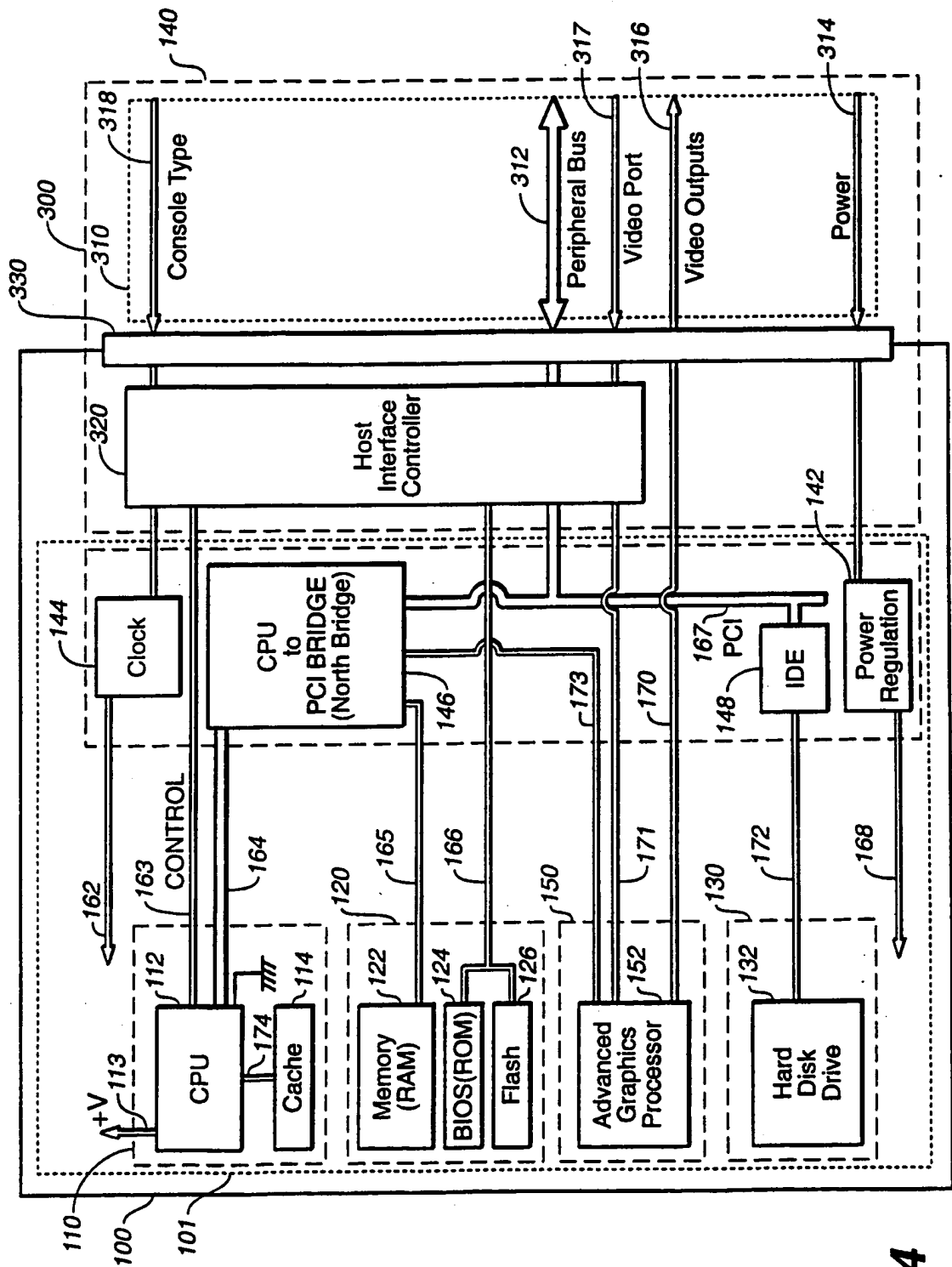
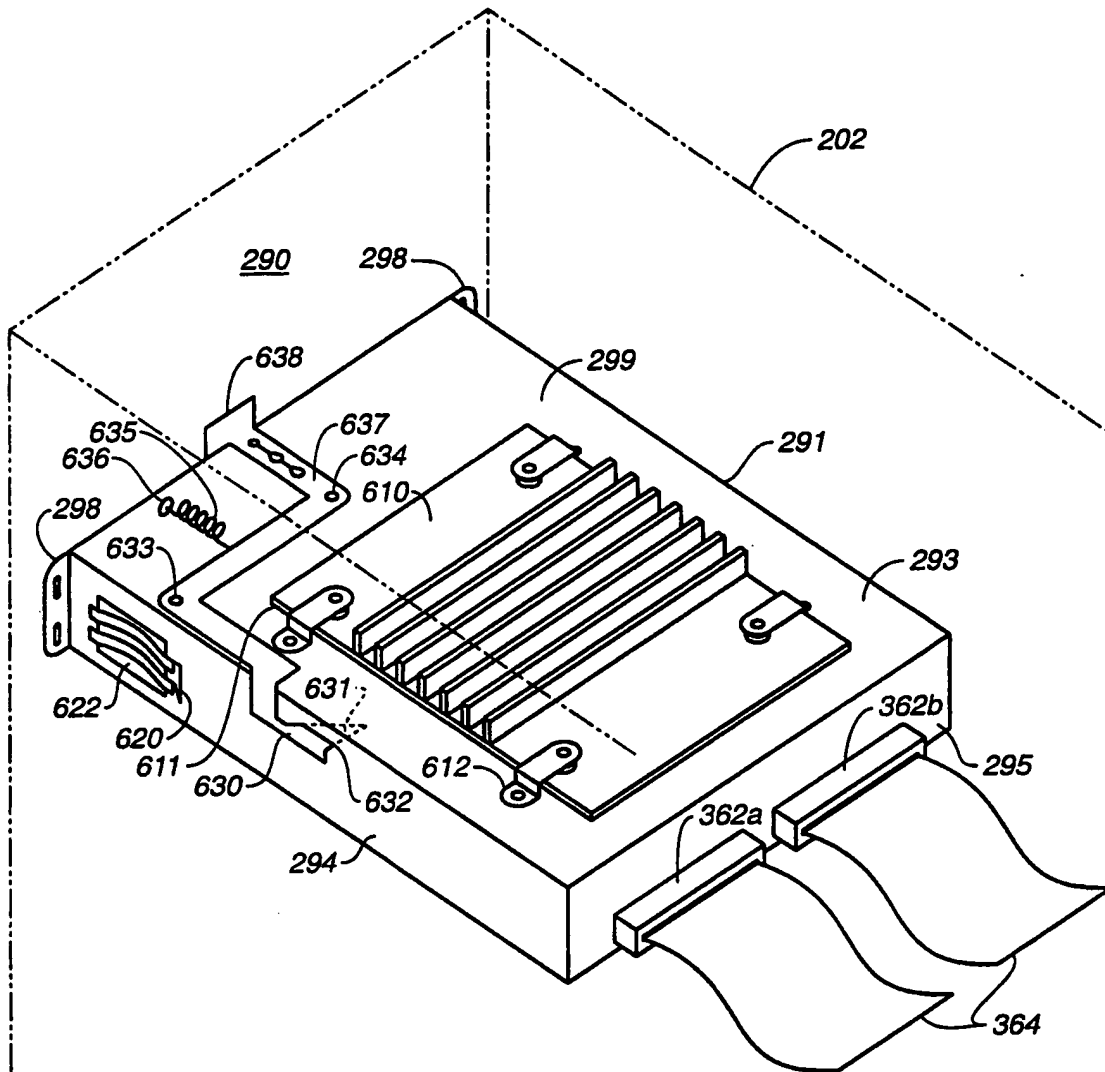


FIG. 4

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**FIG. 5B**

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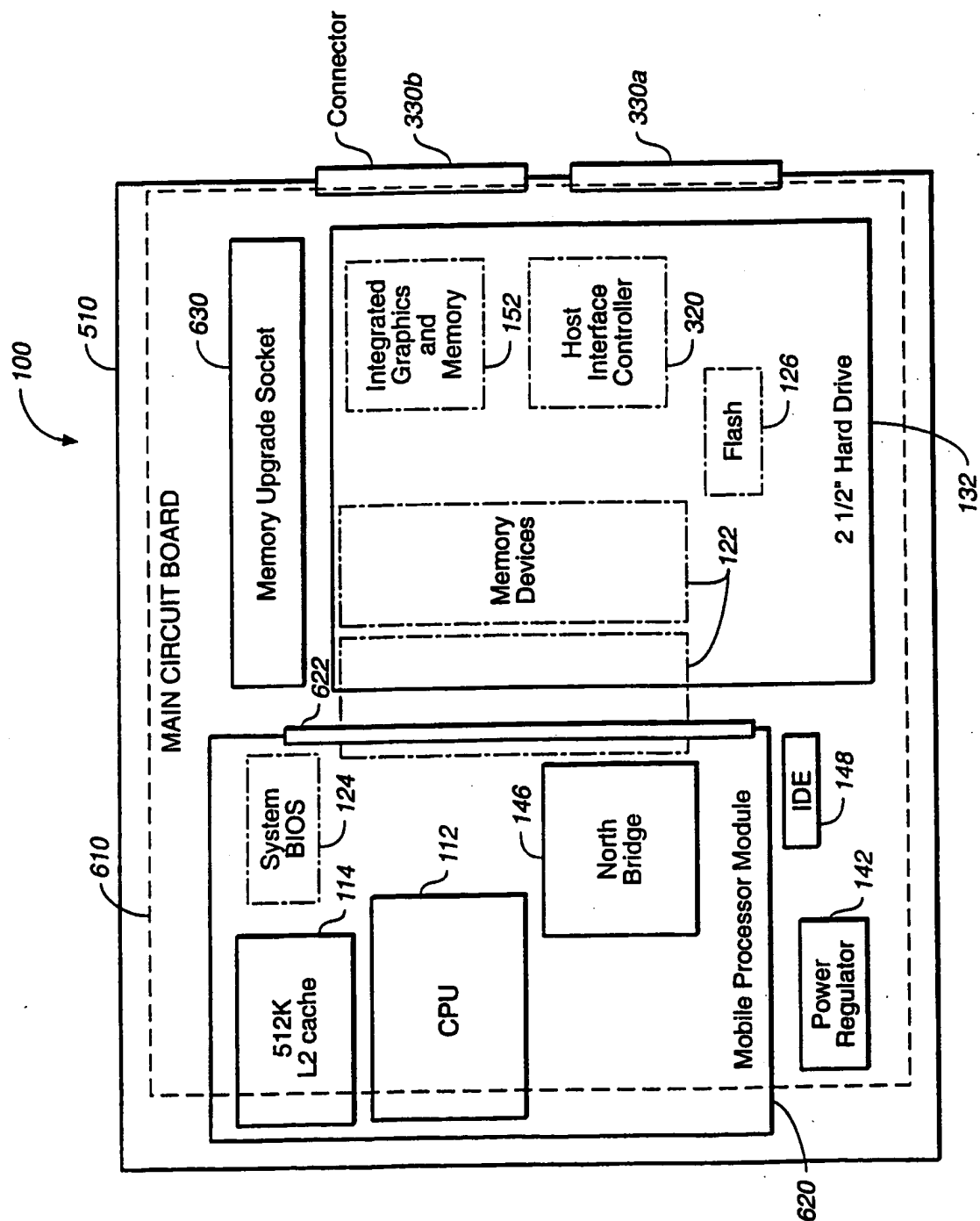


FIG. 6

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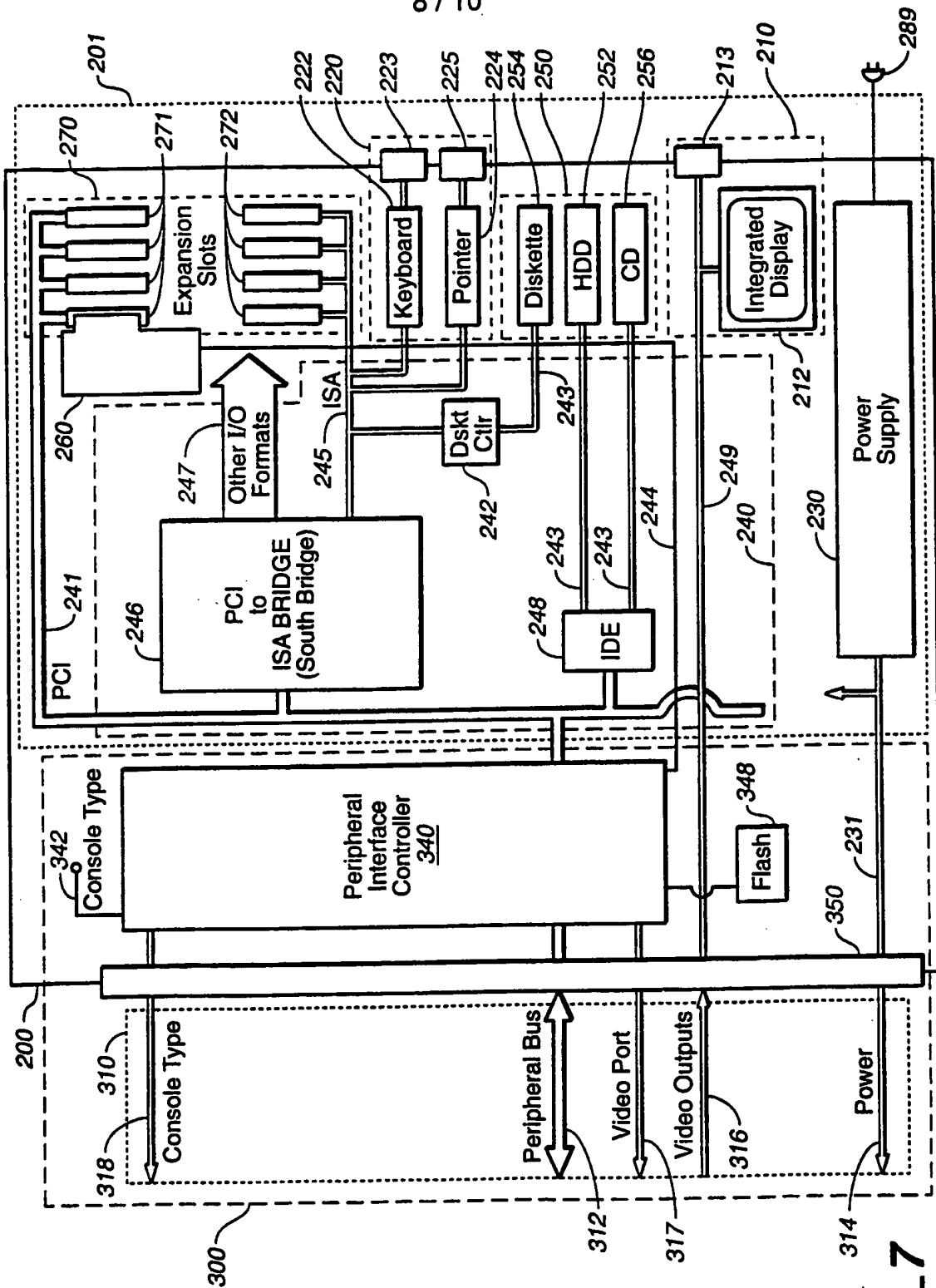
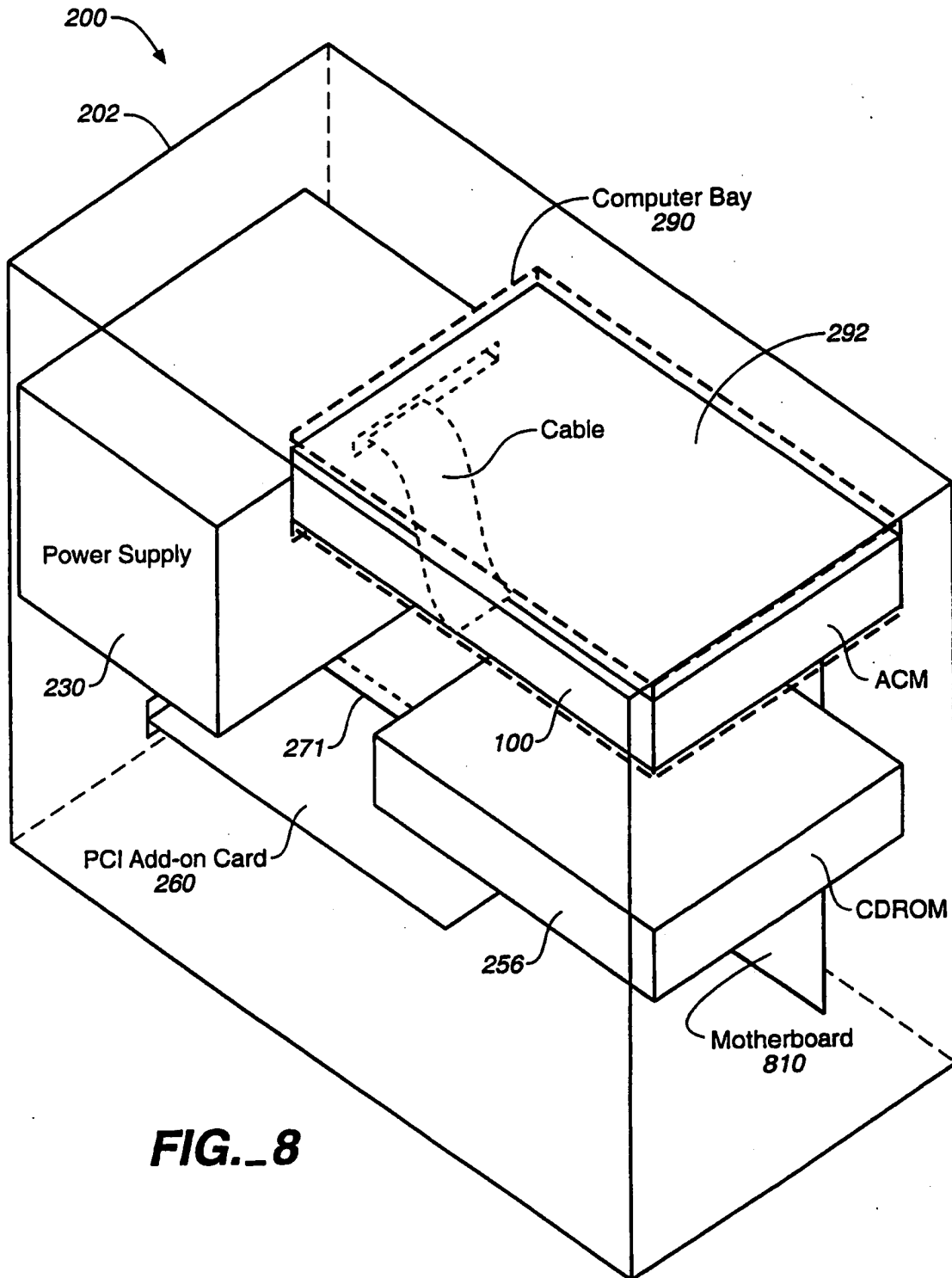


FIG. 7

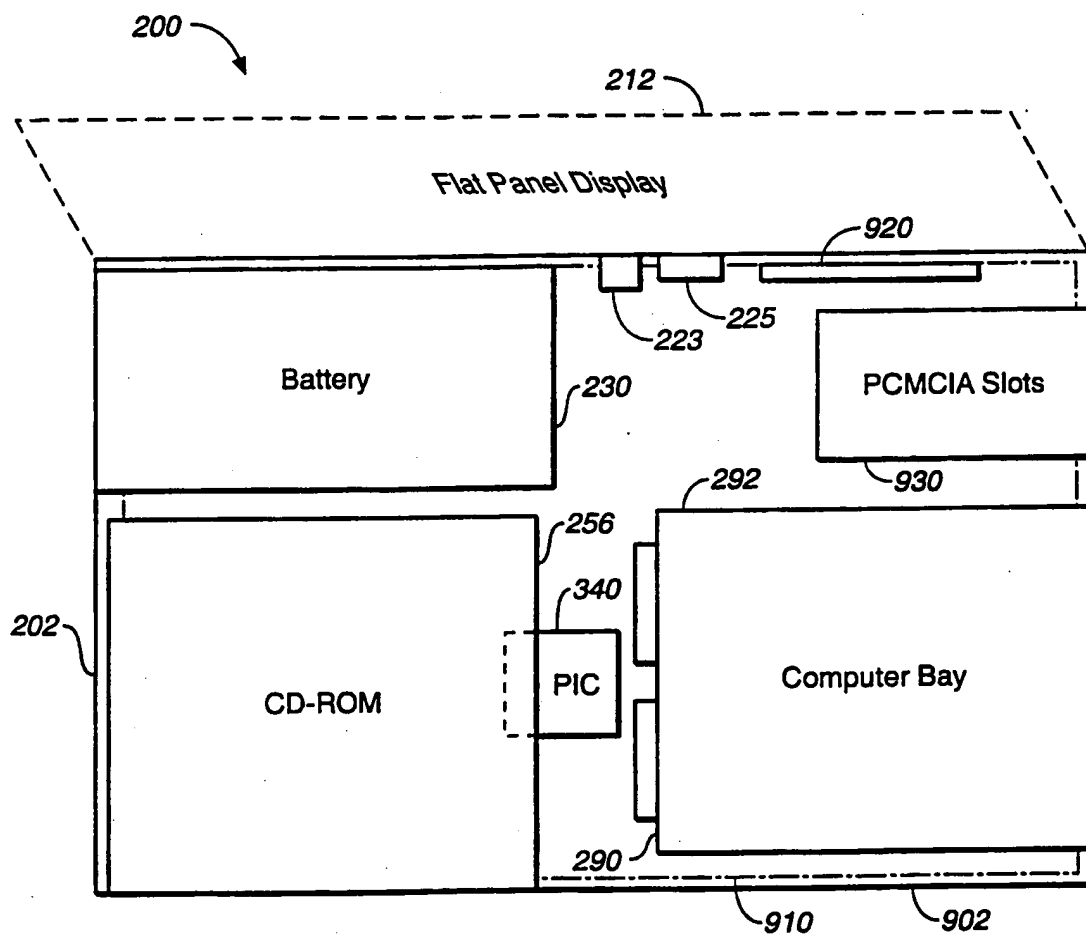
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**FIG. 8**



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**FIG. 9**